RESEARCH HIGHLIGHTS

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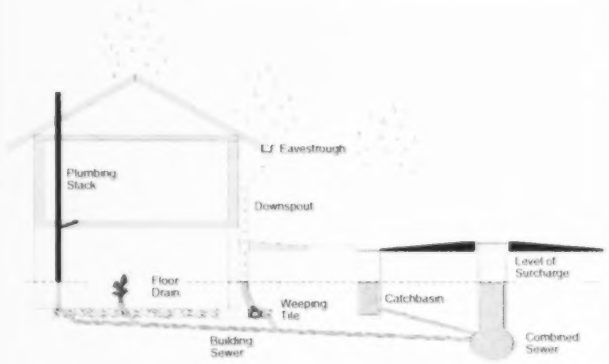
# PRACTICAL MEASURES FOR THE PREVENTION OF BASEMENT FLOODING DUE TO MUNICIPAL SEWER SURCHARGE

## Introduction

This highlight is based on a project funded by the Canada Mortgage and Housing Corporation External Research Program. The project was motivated by concerns for providing adequate levels of protection about unwanted sources of moisture in residential basements that may cause property damage and/or adversely affect the health and safety of the occupants. Requirements in building codes and standards are intended to assure minimum levels of health and safety for aspects such as structural integrity, indoor air quality and fire protection. Evidence indicates that minimum levels of protection against basement flooding due to municipal sewer surcharge are not being uniformly achieved across Canada. In the same way that the probability of structural failure has been set to a socially acceptable threshold within building codes and design standards, measures for the prevention of basement flooding should offer a fairly consistent degree of protection in all buildings. Basement flooding due to municipal sewer surcharge continues to represent a weak link in housing technology and regulation.

Basement flooding is unfortunately a common occurrence in many parts of Canada and is now being recognized as a potentially serious problem. There are many negative consequences associated with basement flooding, above and beyond the inconvenient mess and disruption of household routine. Recent research cites the following impacts:

- Mounting evidence points to significant health risks linking basement flooding with the potential for the growth of molds that may be associated with allergic reactions, asthma episodes and other respiratory problems;
- Frequent occurrences of basement flooding can result in longer term forms of damage to the building and equipment that may not be covered by insurance;
- Insurance rates may rise to compensate for repeated basement flooding claims, and/or the minimum deductible may be increased significantly; and
- Property value may depreciate because the basement is prone to frequent flooding.




**BASEMENT FLOODING DUE TO COMBINED SEWER BACKUP**
Combined sewer backup is the most common form of basement flooding. During periods of heavy rainfall, or snowmelt, the municipal sewer system becomes overloaded and the surcharge backs up and floods basements through low plumbing connections. It is essential to properly clean up the flooded area after the flooding subsides because the sewage may contain numerous harmful bacteria and contaminants.

Basement flooding problems continue to occur in many Canadian municipalities and challenge government, industry and academia for effective mitigation measures. Basement flooding cannot be addressed in isolation because it often represents one symptom among many that stem from municipal drainage systems that are

63413

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not sustainable. Environmental impacts from current approaches to sanitary waste and stormwater management are significant, affecting groundwater, surface water bodies, and the ecosystems they vitally support. Economic impacts associated with municipal infrastructure in Canada, much of which is rapidly deteriorating, are burdensome. Preventing basement flooding involves a deeper understanding of ecosystems, watersheds, municipal infrastructure systems and the diversity of building connection types to these systems. The background needed to understand and appreciate this larger context goes beyond the scope of this research project, however, related sources of information are provided in the final report.

The causes of basement flooding range from existing municipal infrastructure that did not benefit from contemporary urban drainage design strategies, to individual buildings with inadequate sanitary, foundation and/or lot drainage.

At the large system scale, some municipalities have inherited sewer infrastructure in need of improvements that will consume considerable time and investment due to the scale and complexity of the causes underlying their basement flooding problems. At the individual house scale, ineffective site grading and poor design, construction and/or maintenance of the drainage connections further contribute to the potential of basement flooding. In older, inner city neighbourhoods with small lot sizes, illegal connections of the foundation drainage to the sanitary sewer system are often tolerated, as there are no safe and effective means of discharging sumps onto frozen yards.

Due to this diversity, there is no single, simple solution to the problem of basement flooding. Instead, a series of related measures are needed to effectively deal with a particular type of basement flooding problem. For simple cases, individual house measures may prove successful. In more complicated cases, these measures must be coordinated with modifications to the minor drainage system. For the most complex cases, the major drainage system design must be addressed along with some combination of intermediate and individual building measures.

The various strategies, techniques and technologies needed to practically eliminate basement flooding within a particular context are not widely shared, and often difficult to access. The findings of this research project reinforce those of previous related studies that indicate the low level of knowledge and technology transfer initiatives in the area of basement flooding mitigation and prevention. This research report provides a framework for improving basement flooding prevention and protection.

## Methodology

This research project was funded under CMHC's External Research Program. Work commenced in May 2001 and was substantially completed by December 2002. Research methods employed in this project consisted of a literature review and municipal surveys. The literature review was conducted using the University of Toronto's library services (electronic database search facilities), in parallel with an electronic search of CISTI. Searches of Internet resources followed once a base of key words and terminology was culled from the literature review. A review of product literature in the areas of backflow prevention devices and sump pumps was also conducted to identify available mitigation products and technologies.

Surveys were developed and forwarded to a number of Canadian municipalities that were identified via prior letters of interest and subsequent telephone contacts. Municipalities and key contacts were identified through the Federation of Canadian Municipalities database. All surveys were subsequently followed-up with telephone interviews. The surveying was initiated in the summer of 2001 and results continued to be received up to the end of September 2002.

This project was limited to residential basements in Canada that have sanitary and/or storm connections to municipal infrastructure that are prone to surcharge during extreme rainfall and/or snow melt events. The work focused on practical measures currently available to existing homeowners experiencing basement flooding problems, and builders constructing new homes within sewer surcharge-prone areas. Contributing factors influencing the severity of this problem were also investigated for aspects pertaining to the dwelling and immediate surrounding property (grading, conveyance, storage, and inflow/infiltration). Successful and cost-effective measures undertaken by municipalities in regard to modifications to existing municipal drainage systems were also surveyed.

The objectives of this project included:

1. Up-to-date literature review of basement flooding problems due to sewer surcharge, including any evidence of remedial or preventive mitigation measures.
2. Illustrated and/or photographed, technical documentation of sewer surcharge mitigation measures which have been successfully deployed in Canada, or elsewhere, and which are available to existing homeowners and builders.
3. Documentation of successfully deployed mitigation measures at the municipal infrastructure level.
4. Identification of technical and/or regulatory barriers associated with these mitigation measures.

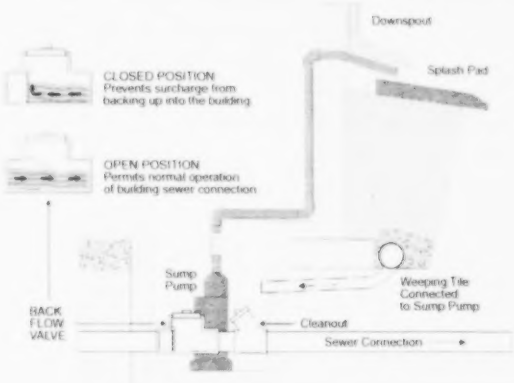
## Findings

Key findings of this research project indicate that many of the issues, identified as long as two decades ago, have yet to be effectively addressed.

1. Inadvertently, past practices for the design of Canadian municipal sanitary sewer and stormwater drainage systems often created an off-line storage network for surcharges called basements.
2. Most municipalities in Canada experience basement flooding problems due to municipal sewer surcharge, and the majority of causes for these flooding problems are systemic.
3. Basement flooding related insurance claims in Canada are estimated to be in the order of $140 million per year based on a multi-year average. This represents an average of approximately 30,000 to 40,000 incidents per year, with an average cost of damages per flooding incident between $3,000 and $5,000.
4. Mounting evidence points to significant health risks linking basement flooding with the potential for the growth of molds that may be associated with allergic reactions, asthma episodes and other respiratory problems. Economic impacts related to health care and productivity have yet to be assessed.
5. Canadian municipalities have developed and implemented a number of successful approaches to protection of basements against flooding. Three major aspects of protection measures were identified: i) the individual dwelling; ii) the minor system (the neighbourhood or sub-division, as defined by its local drainage system); and iii) the major system (municipal or regional level). Integrating protection measures across all three levels is key to a successful basement flooding protection program.
6. There is still no central repository of basement flooding protection knowledge and precedents currently available to urban drainage system designers, and no established forum for the exchange of information was identified during this research project.
7. The trend in basement flooding prevention programs is very encouraging among the municipalities surveyed, and most municipalities in Canada have implemented, or are soon initiating, formal prevention programs that include various media for public education/information.
8. Advances in backflow prevention devices (backwater valves) and sump pump technologies offer homeowner's effective and reliable levels of protection against basement flooding, however codes and standards for their performance and installation are lagging.
9. Lack of applied research, inadequate technology transfer, gaps in codes and standards, and municipal accounting practices represent the primary barriers to progress in the mitigation of basement flooding problems.

In summary, despite the lack of a coordinated program among Canadian municipalities and government bodies for basement flooding protection due to municipal sewer surcharge, significant improvements have been achieved by individual municipalities. Further progress hinges on:

- additional funding for both infrastructure improvements and support of programs for exchanging knowledge;
- coordinating research and development efforts; and
- addressing gaps in codes and standards.




**BACKFLOW VALVES AND SUMP PUMPS ARE EFFECTIVE MEANS OF AVOIDING BASEMENT FLOODING**

A survey of Canadian municipalities found that for existing homes experiencing basement flooding due to sewer backup, an effective prevention strategy is to install a sump pump and a back flow valve. This type of installation must normally be approved by the municipality and it is recommended to have the work performed by a qualified plumber.

## Possible Actions

The following possible actions could be considered by all stakeholders concerned about basement flooding issues.

1. Federal, provincial, municipal and consumer stakeholders could pursue the development of criteria and requirements to be integrated within existing national codes and standards that address basement flooding protection measures. In particular, requirements for site and foundation drainage in the National Building Code of Canada (NBC), and sanitary and stormwater provisions in the National Plumbing Code of Canada (NPC) could be examined and amended as required, in order to reasonably "*ensure that buildings are free of health hazards*".

2. Public sector funding aimed at assembling and maintaining the basement flooding prevention and mitigation knowledge base, and institutionalizing a forum for the exchange of experiences and ideas could be established. The Federation of Canadian Municipalities could confer with other public sector stakeholders to obtain funding and coordinate a national basement flooding protection program.

3. To further the effectiveness of the basement flooding protection program outlined above, public sector funding for strategic research could be provided to develop and disseminate standards and best practices for the design (computer simulation, modeling, monitoring) of urban drainage systems and for the performance and proper installation of basement flood protection measures (backflow valves, sump pumps, etc.).

4. Research and development of innovative technologies for sustainable urban infrastructure could be encouraged. This initiative should include empirical studies, similar to those conducted in the U.S., to establish the effectiveness of "*landscape as infrastructure development*" techniques and low impact development models on sanitary and stormwater management. Results from this R&D process should be made available in a format that is suitable to designers (parametric computer simulation) and regulatory authorities to eliminate technical and regulatory barriers to innovation.

5. Consumer protection against the risk of property damage and exposure to health hazards could be improved beyond present levels. Homebuyers and rental tenants need to reliably and conveniently determine the flooding history and level of basement flooding risk for any property in a timely fashion. A household needs to know if it is vulnerable to a different level of, say, protection for structural failure or electrical shock than for basement flooding and should know if their basement is in a flood prone area.

6. Stakeholders, such as CMHC, Federation of Canadian Municipalities, Insurance Bureau of Canada, Consumers Council of Canada, etc., could establish a reliable means of reporting and monitoring the status of basement flooding events and mitigation measures across Canada, and support necessary improvements through appropriate research and development initiatives.

Basement flooding apparently continues to be accepted by a Canadian public that is largely unaware of its potential health implications. Sufficient evidence exists to support all levels of government in reasonably responding to this problem, and developing effective programs aimed at the practical elimination of basement flooding within a threshold of probability that is congruent with those applied to other health and safety measures in housing and buildings.

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